MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2215)

EMG2016 – ELECTROMAGNETIC THEORY

(RE)

15 FEBRUARY 2023
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 8 pages excluding cover page with 4 questions only.
2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the answer booklet provided.
4. Please tear off and attach your completed Smith Chart in the answer booklet.

QUESTION 1

a) What is a transmission line? When should transmission-line effects be considered?

[4 Marks]

b) A 1-GHz parallel-plate transmission line consists of 1.2cm-wide copper strips separated by a 0.15-cm-thick layer of polystyrene. Determine the line parameters of the transmission line.

Copper: $\mu_c=\mu_0= 4\pi \times 10^{-7}$ (H/m); $\sigma_c \approx 5.8 \times 10^7$ (S/m)
Polystyrene = $\mu=\mu_0 = 4\pi \times 10^{-7}$ (H/m); $\sigma \approx 0$; $\varepsilon_r = 2.6$

[8 marks]

c) A lossless transmission line with $Z_0=50\Omega$ is 0.35λ and operates at 2MHz. The line is terminated with a load $Z_L = 70 - j40$. If u = 0.6c on the line, find

(i) The wavelength, λ

[2 marks]

(ii) The length of the line in meter

[1 mark]

(iii) The reflection coefficient

[3 marks]

(iv) The standing wave ratio

[2 marks]

(v) The input impedance, Z_{in}

[5 marks]

Continued...

QUESTION 2

a) Name the fundamental law related to the following Maxwell equation.

(i) $\nabla \times \boldsymbol{E} = -\partial \boldsymbol{B}/\partial t$

(ii) $\nabla . \boldsymbol{B} = 0$

(iii) $\nabla \times \boldsymbol{H} = J + \partial \boldsymbol{D}/\partial t$

[3 marks]

a) State the three situations that will induce V_{emf}

[6 marks]

b) A rod of length 0.25m and parallel to xy plane as shown in figure below is moving with velocity of $\mathbf{u} = \hat{x}5\ (m/s)$. If static magnetic field of $\mathbf{B} = \hat{z}10\ (T)$ is applied,

(i) Find the induced Vemf on the rod.

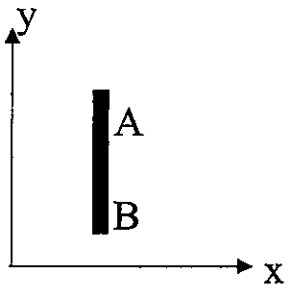
[6 marks]

(ii) State which end is at higher potential.

[2 marks]

(iii) If the rod has a velocity of $\mathbf{u} = \hat{z}5\ (m/s)$ instead, find the emf induced. Explain your answer.

[2+2 marks]



c) Find the displacement current density, $\mathbf{J_d}$, if given E = $\hat{y}$ 10 cos (ωt – 50 x) V/m in free space.

Hint: $\mathbf{D} = \varepsilon \mathbf{E}$

[4 marks]

Continued...

QUESTION 3

a) Given an electric field $\mathbf{E} = \hat{y}\ 30 \cos(\omega t + \beta x)$, propagating in a medium with $\varepsilon_r = 9$, $\mu_r = 4$, find the following:

i) Electric field in phasor form, $\tilde{E}$

[2 marks]

ii) The corresponding magnetic field, **H** in time domain

[5 marks]

iii) Magnetic field in phasor form, $\tilde{H}$

[2 marks]

iv) The Poynting vector, **S**

[3 marks]

v) The Average Power Density, $\mathbf{S}_{av}$

[3 marks]

b) The electric field phasor of a uniform plane wave is given by $\tilde{E} = \hat{y}10ej0.2z$ (V/m). If the phase velocity of the wave is 1.5×10^8 m/s and the relative permeability of the medium is $\mu_r = 2.4$, find the following:

i) The wavelength, λ.

[2 marks]

ii) The frequency of the wave.

[2 marks]

iii) The relative permittivity of the medium, ε_r.

[3 marks]

iv) The time-domain electric field **E**(z,t).

[3 marks]

Continued...

QUESTION 4

a) Explain the difference between TEM and TE waves in a uniform waveguide.

[3 marks]

b) In an air-filled rectangular waveguide, a TE mode operating at 6 GHz has

$$E_y = 5\sin\left(\frac{2\pi x}{a}\right)\cos\left(\frac{\pi y}{b}\right)\sin(\omega t - 12z) \quad \text{V/m} .$$

The speed of light in air is about 3×10^8 m/s. Determine:

(i) the mode of operation,

[2 marks]

(ii) the free space phase constant,

[2 marks]

(iii) the waveguide phase constant,

[2 marks]

(iv) the cutoff frequency,

[4 marks]

(v) the TE wave impedance, and

[4 marks]

(vi) H_x

[4 marks]

c) Determine the dimension of the cubical cavity which operates at a resonant frequency of 4 GHz, when excited at the TE_{101} mode.

[4 marks]

Continued...

Appendix : Physical constants

Constant	Symbol	Value
Speed of light in vacuum	c	$3x10^{8}$ m/s
Permittivity of free space	ε_o	$8.8542x10^{-12}$ F/m
Permeability of free space	μ_o	$1.2567x10^{-6}$ N/A^2
Intrinsic impedance of free space	η_o	377Ω

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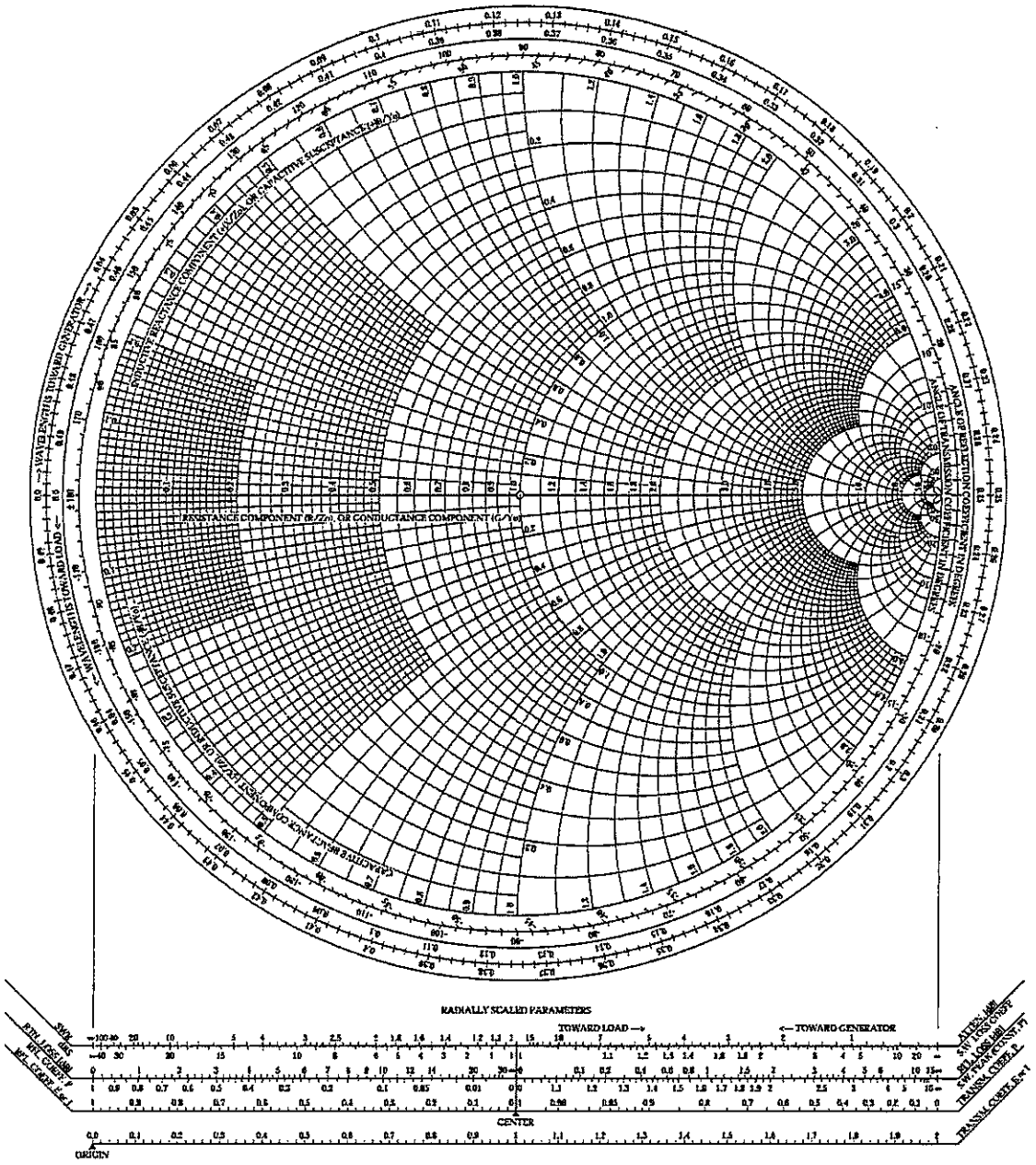
The Complete Smith Chart

Black Magic Design



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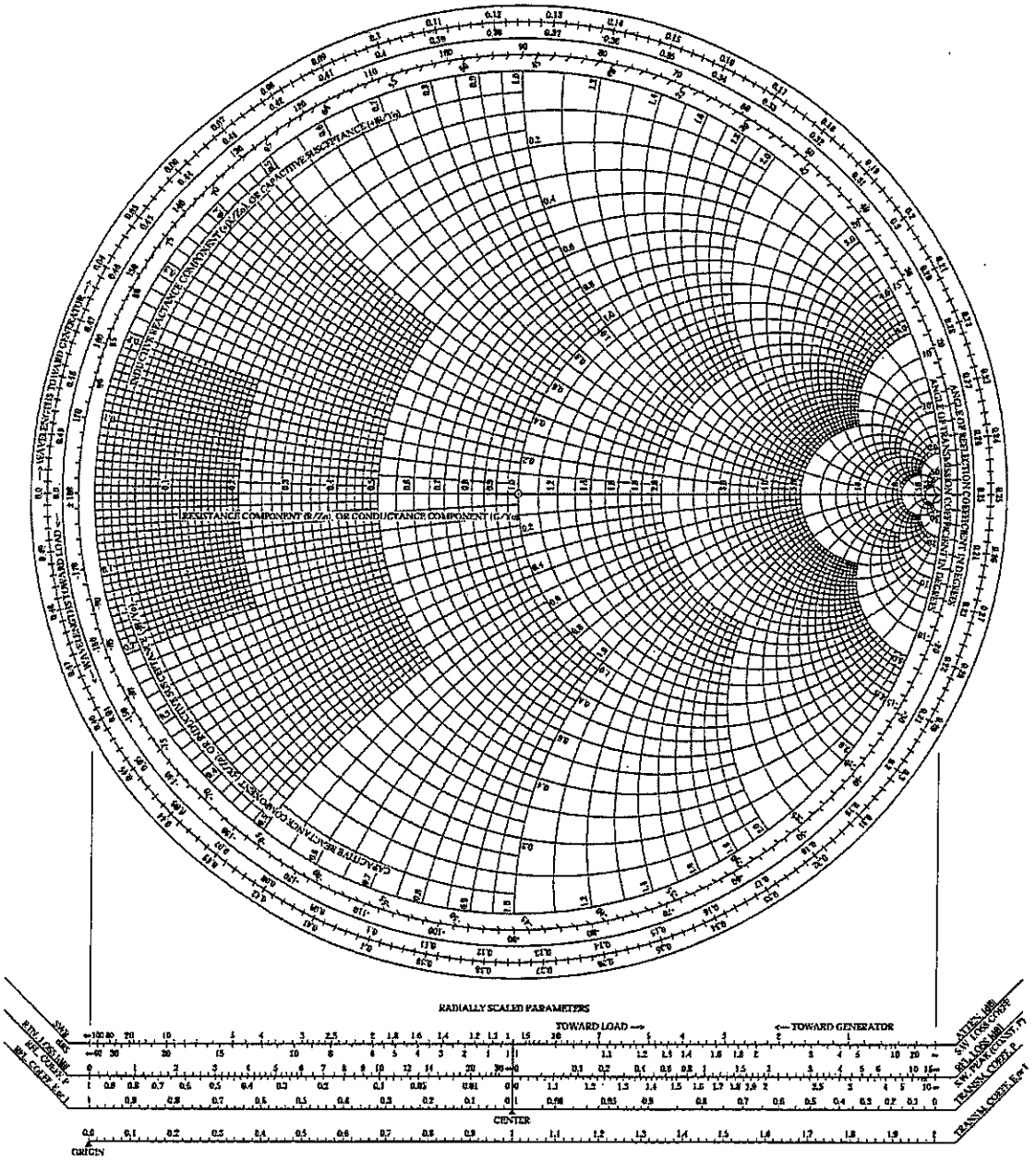

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The Complete Smith Chart

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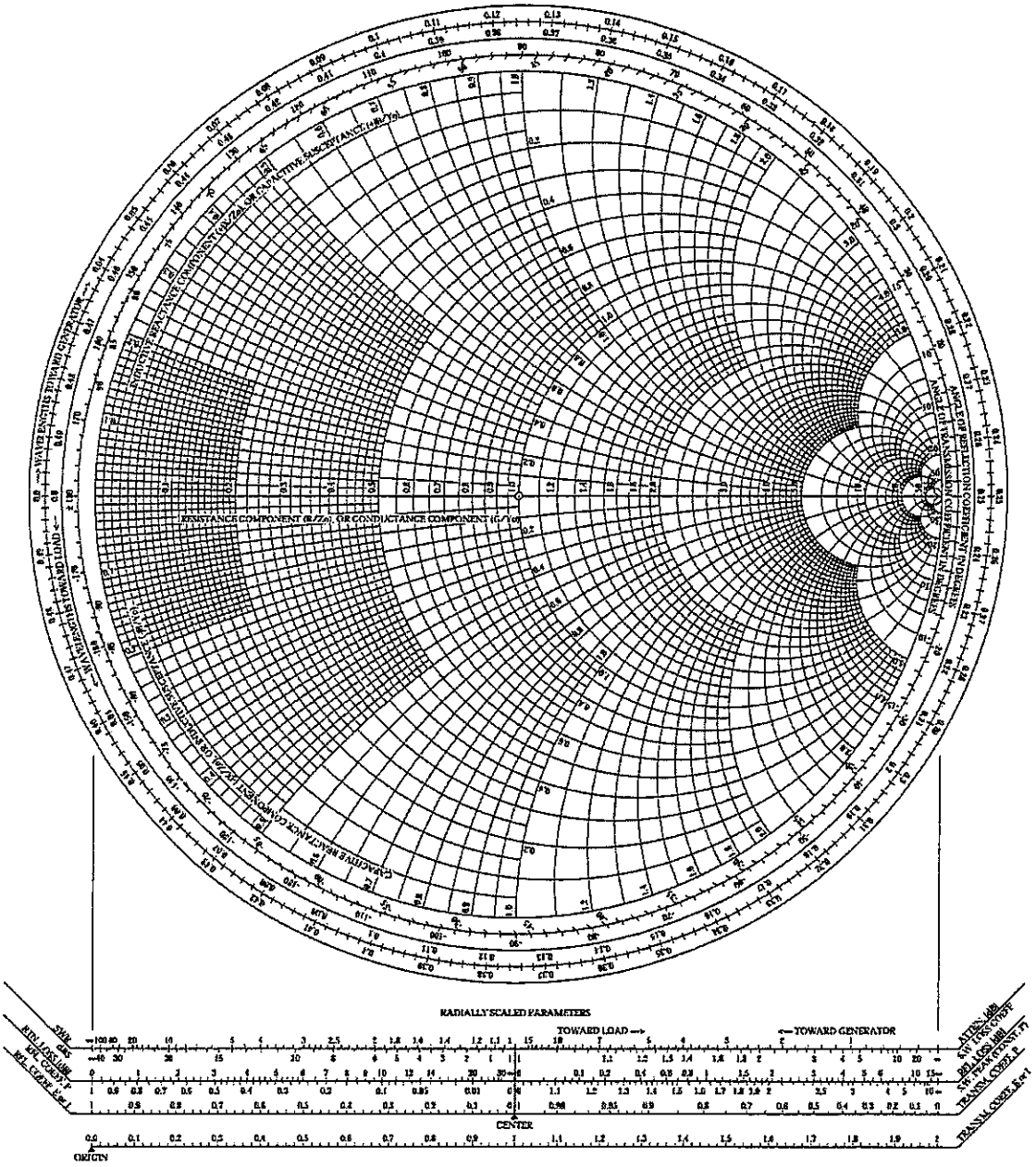

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